Snowmass TDAQ Subgroup “Hello!”

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Outline

- Overview of TDAQ challenges and topics of interest
- Planned TDAQ subgroup activities
- TDAQ subgroup communication

Who we are

- Darin Acosta
    - University of Florida, Department of Physics
    - CMS experiment, Level-1 muon trigger, incoming Trigger co-coordinator
- Wes Ketchum
    - Fermilab, Scientific Computing Division
    - MicroBooNE, SBN, and DUNE experiments, LArTPC DAQ and *artdaq* framework
- Stephanie Majewski
    - University of Oregon, Department of Physics
    - ATLAS experiment, LAr calorimeter trigger electronics

Some previous collection of discussion

- European Strategy Physics Book (see Secs. 11.1 and 11.2): https://cds.cern.ch/record/2691414/files/Briefing_Book_Final.pdf
- CPAD 2018 Report (see Secs. 4.7, 4.10.5-7): https://arxiv.org/pdf/1908.00194.pdf
    - 2017 CPAD DAQ Workshop: https://indico.fnal.gov/event/14744/
- TDAQ Community Meeting for DOE Basic Research Needs (2019): https://agenda.hep.wisc.edu/event/1430/
- Please feel free to send us more!

TDAQ Challenges

Next generation of detectors places many challenges on Trigger and DAQ

- Large data throughput
- High reliability and performance in extreme environments
- Fast timing and precise synchronization, even across large distances

We should consider advances on many possible lines

- Novel improvements on existing technologies and techniques
- Exploring and advancing emerging technologies
- Integration of TDAQ requirements, capabilities, and possibilities, into R&D efforts across instrumentation frontier and future detector design

Some specific TDAQ topics of interest (1)

- Future experiments are growing in scale, and will generate data at 100s of TB/s in challenging environments
    - E.g. high radiation, magnetic fields, cold temperatures, severe limitations on space and power
- High-speed data links for future detectors
    - Improved rad-hard optical links, photonics-based links, and wireless readout among possible solutions, but all need R&D
- Real-time on-detector processing hardware
    - Low-power ADCs ready to meet demands of faster sampling and high resolution need orders of magnitude improvement
    - Need localized data reduction, processing, and aggregation: e.g. FPGAs and ASICs for 'low-level' compression/zero suppression and 'high-level' clustering and pattern-finding
    - Incorporating precise timing into readout and triggering for handle pileup, improved particle ID

Some specific TDAQ topics of interest (2)

- Needs for high-level triggering and monitoring of detectors are increasing with detector size and event complexity, requiring advanced computing

- Online processing and improved high-level trigger algorithms
  - Development of online and real-time algorithms that can make further use of heterogeneous computing (CPU, GPU, FPGA, etc.), and tools to make that possible (e.g. HLS)
  - Includes artificial intelligence/machine learning/neuromorphic computing algorithms and fast inference
- Autonomous systems for operation, calibration, and control
  - Anomaly detection, fault recovery, and automated calibration for detector stability and efficient DAQ will be critical for complex detectors and high uptime demands
  - Prime place to take advantage of AI/ML techniques to automate feedback

Some specific TDAQ topics of interest (3)

- Architecture of DAQ systems is evolving with needs of large detectors and improvements in readout electronics and computing

- Precision synchronization
    - Precise timing creates need for ~picosecond synchronization of detector components for event/interaction disambiguation, phase coherence, and absolute time comparisons at km and greater scales
- Solutions for system-level architecture improvements in DAQ
    - “Streaming” and asynchronous readout components allow for more R&D in shared readout techniques and technologies (e.g. “computing-as-a-service” with well-defined latencies for high-level event filtering)

Some specific TDAQ topics of interest (4)

- And of course, your further ideas here!

Key overlap/shared concerns with other (sub)groups

- TDAQ necessarily takes as input the requirements of the detectors
    - Electronics/ASICs a key integration point, but systems-level understanding critical for making an experiment work

- TDAQ not only makes use of advancements in computing, but is a key driver for what the needs of offline computing are
    - Parallelized algorithms and machine learning critical to future online triggering algorithms
    - Balance the abilities of TDAQ with the abilities for offline computing, networking, and storage to keep up

- Of course, connections to all groups/frontiers critical for building the detectors, facilities, and communities to achieve our physics goals

TDAQ Subgroup Planned Activities

- Brief welcome call in early July
  - Gather TDAQ enthusiasts across HEP to find our community, elaborate our goals for this forum, and encourage collaboration and discussion
  - Likely ask for people to prepare brief “one-slide” on who they are and their interests, plans, and ideas
  - Discuss organization for future work to help our community

- Dedicated TDAQ virtual meeting in early August
  - Solicit brief presentations of LOI ideas to encourage feedback and collaboration
  - Following July meeting, organize session(s) for broader discussion of needs in TDAQ
    - Particularly “what’s missing” from the presented ideas and plans

Communication

- We've been working on sending emails to collaborations/TDAQ enthusiasts across HEP
    - We need your help! Please don't hesitate to spread the word or encourage us to contact others: hopefully these slides are a good intro to share!

- Subscribe to our email list: SNOWMASS-IF-04-TDAQ@FNAL.GOV
- Slack channel: #if04-tdaq
- Wiki page: https://snowmass21.org/instrumentation/trigger
    - (which we will attempt to keep updated with important info...)

Backup

Some specific thrusts

- High-speed data links and transfers
- Real-time processing hardware
  - Heterogeneous (ASIC, FPGA, GPU, CPU)
- Architecture (triggered vs. streaming, synchronous vs. asynchronous, how our computing is distributed ‘computing as a service’)
- Online processing and improved high-level trigger algorithms
- Autonomous systems for operation, control, and calibration
- Precision timing for improved triggering and synchronization
- Make sure to get the difference in needs for different frontiers (high energy, neutrino, intensity, cosmic)